REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE 11/15/1999	3. REPORT TYPE AND DATES COVERED Final Progress Report 05/01/98-10/31/98

4. TITLE AND SUBTITLE
Wideband EMI modeling for buried unexploded ordnance

5. FUNDING NUMBERS
DAAG55-98-1-0299

6. AUTHOR(S)
Lawrence Carin

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Duke University
Department of Electrical and Computer Engineering
Durham, NC 27708-0291

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U. S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

ARO 38691.2-EL

11. SUPPLEMENTARY NOTES

The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.

12 a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12 b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

A method-of-moments (MoM) model is developed for electromagnetic induction (EMI) signatures of conducting and possibly ferrous targets that are bodies of revolution (BoRs).

14. SUBJECT TERMS moment method, induction			15. NUMBER OF PAGES 3
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT **UNCLASSIFIED**	18. SECURITY CLASSIFICATION ON THIS PAGE **UNCLASSIFIED**	19. SECURITY CLASSIFICATION OF ABSTRACT **UNCLASSIFIED**	20. LIMITATION OF ABSTRACT **UL**

I. List of Manuscripts Submitted/Published under ARO Support

N. Geng, C. E. Baum and L. carin, "On the low-frequency natural response of conducting and permeable targets," IEEE Trans. Geoscience & Remote Sensing, vol. 37, pp. 347-359, Jan. 1999.

II. Scientific Personnel

Faculty: Lawrence Carin (PI)
Post doc: Norbert Geng

III. Invention Reports

None

IV. Scientific Progress and Accomplishments

A circuit-based analysis of low-frequency, electromagnetic scattering from conducting targets has been presented, from which it was demonstrated that the late-time (natural) response from such targets is represented by an exponentially damped response. A rigorous, MoM analysis was then applied to the case of conducting, permeable BORs in free space, for which the damped natural response was demonstrated as still appropriate. Moreover, the MoM-computed decay constants were found to be in good agreement with measured data.

Several important relationships were derived and demonstrated: i) for a conducting, non-permeable target, the modal decay constants were shown to scale with conductivity, and therefore results need only be computed for a representative conductivity, assuming the target shape remains constant; ii) the decay constants (with m=0) for highly permeable and conducting targets can be computed very accurately (<1% error) using a simple resonant-cavity analysis (particularly useful for simple shapes such as cylinders and discs); and iii) the Cramer-Rao lower bound for estimation of the decay parameters can often be simplified to a simple relationship which only depends on the SNR (computed from the noise variance and the decay coefficient). These relationships allow one to perform quick "back-of-the-envelope" computations of the system requirements for unambiguous target discrimination via decay-parameter estimation. In this context, for the examples considered here, we have found that an SNR of roughly 20dB is required.

The low-frequency, decay-constant discrimination of conducting, permeable targets has many applications. For example, one can use it for concealed-weapon *identification* [31] as well as for identification of buried metal mines (in which case discrimination mitigates the need to dig up each piece of anthropic metal clutter). With regard to the latter example, the effects of the lossy soil become important as the size of the metal target

diminishes (this is especially relevant for plastic mines which posses very small metal content). Therefore, in future work we will consider the BOR targets buried in a lossy half space. This problem constitutes a significant escalation in complexity, due to the need to compute the half-space dyadic Green's function.

V. Technology Transfer

The research reported here has been undertaken in close collaboration with the Corps of Engineers (Vicksburg, MS) and the BoR code is now used by them routinely.